STRATEGY FOR RANKING THE SCIENCE VALUE OF THE SURFACE OF ASTEROID 101955 BENNU FOR SAMPLE SITE SELECTION FOR OSIRIS-REx K. Nakamura-Messenger[1], H C. Connolly Jr.[2,3,4,5], D. S. Lauretta[5] and the OSIRIS-REx Science Team. [1]Robert M. Walker Laboratory for Space Science, ARES, NASA JSC, 2101 NASA parkway, Houston TX 77058 keiko.nakamura-1@nasa.gov; [2]Dept. Physical Sciences, Kingsborough Community College of CUNY, 2001 Oriental Blvd., Brooklyn N.Y. 100235, USA; [3] Earth and Environmental Sciences, The Graduate Center of CUNY, 365 5th Ave., New York, New York, 10016, USA; [4]Dept. Earth and Planetary Sciences, AMNH, Central Park West, New York, NY 10024, USA; [5]Lunar and Planetary Laboratory, Univ. of Arizona, Tucson, AZ 85721, USA.

OSRIS-REx is NASA's New Frontiers 3 sample return mission that will return at least 60 g of pristine surface material from near-Earth asteroid 101955 Bennu in September 2023. The scientific value of the sample increases enormously with the amount of knowledge captured about the geological context from which the sample is collected. The OSIRIS-REx spacecraft is highly maneuverable and capable of investigating the surface of Bennu at scales down to the sub-cm. The OSIRIS-REx instruments will characterize the overall surface geology including spectral properties, microtexture, and geochemistry of the regolith at the sampling site in exquisite detail for up to 505 days after encountering Bennu in August 2018. The mission requires at the very minimum one acceptable location on the asteroid where a touch-and-go (TAG) sample collection maneuver can be successfully performed. Sample site selection requires that the following maps be produced: Safety, Deliverability, Sampleability, and finally Science Value. If areas on the surface are designated as safe, navigation can fly to them, and they have ingestible regolith, then the scientific value of one site over another will guide site selection.

Identification of the best scientific value area: A primary goal of the OSIRIS-REx mission will be to test many hypotheses on the origin, geological history and dynamical evolution of asteroid Bennu through coordinated analytical studies of the returned samples [1]. Bennu is classified as a B-type asteroid and is spectrally similar to CI and CM chondrite meteorites [2]. The returned samples are thus expected to contain primitive Solar System materials that formed both before and after the asteroid accreted. The best scientific value area for sample collection should be the omnibus of the diversity of chemistry, mineralogy and geology of Bennu. In other words, sampling sites with the best scientific value should contain as many key materials as possible to solve the questions/hypotheses posed by the sample analysis working team of OSIRIS-REx [1]. Here we summarize our strategy for selecting and characterizing sample sites on Bennu based on their primary science value.

Integrated Science Value Map (ISVM: Fig.): Overall Science Value assessment will be based on the visual data product of the ISVM that will rank the scientific value of candidate sampling locations within a 2 sigma sample targeting ellipse on the surface of Bennu according to a semi-quantified science value scale. We will produce 3 series of ISVMs; (1) Global, defined by the overall shape model for Bennu down to 1 m resolution, (2) up to 12 reconnaissance sites at cm scales, and (3) up to 4 final candidate sampling sites down to sub-cm resolution. Below we described the four Science Value Maps that to feed into the ISVMs, arranged according to mission priorities:

1) Science Value Chemical Composition Map (SVCCM) will rank the science value of sites on the surface of Bennu according to their chemical composition, with emphasis on the nature and abundances of organic matter. The SVCCM is derived from visual, IR, and thermal emission data taken on the surface of Bennu by OVIRS [3] and OTES, the on-board spectroscopic instruments. The primary parameters that we have identified for the SVCCM are: (1) the detection and abundance of organics and volatiles, (2) the organic/silicate ratio, and (3) the CH_2/CH_3, if detected. The organic/silicate ratio will give us insights into whether organic materials are uniformly distributed on Bennu or if organic-rich regions are present. The CH_2/CH_3 ratio is a method for measuring the length of aliphatic hydrocarbons, where lower CH_2/CH_3 ratios are indicative of more primitive material [4]. We will compare these data with the properties of primitive carbonaceous chondrites and IDPs.

2) Science Value Mineralogy Map (SVMM) will rank the science value of candidate sampling locations according to their mineralogy and mineralogical diversity. This is further subdivided into Mineralogy and Crystalline/Amorphous ratio. For the former, we have listed the mineral species in priority order: phyllosilicates, carbonates, sulfates, oxides, silicates, amorphous, and unknown spectra with significant spectral peaks.

Amorphous silicates are associated with the most primitive Solar System bodies. Amorphous silicates are common in anhydrous interplanetary dust particles (IDPs) and the most primitive meteorites [5-7]. Amorphous silicates are quickly altered by parent-body hydrothermal alteration [8], so their presence may indi-

cate the presence of preserved nebular condensates and/or interstellar materials.

Since Bennu is likely a parent body of primitive meteorites and/or similar to comets [1], amorphous silicates are expected to be in the surface of Bennu. The Crystalline-to-Amorphous Silicate ratio will provide information on the nature and primitiveness of the surface of Bennu.

3) Science Value Geological Feature Map (SVGFM) is essentially a proxy for potential freshness of the surface of Bennu. It is a science priority to collect fresh surface material that hasn't experience extensive space weathering and impact events because these processes may obscure the information recorded in the asteroid sample. This category is further divided into 5 subcategories, the first being plume activity that ejects material from the asteroidal interior. We are interested in being able to discern the differences between active, recent, and Paleo-events. Even through safety may demand that we do not approach any active plumes, it is still the highest science priority followed closely by evidence of recent activities. Space weathering is the next in the order of importance for SVGFM and is subdivided into less than the global average and more than the global average. Particle size frequency distribution is presented as having three major subcategories: mix, course, and fine. Brittle deformation features are next followed by Craters, which is divided into recent and paleo-craters, with recent potentially offering the freshest excavation of regolith.

4) Science Value Temperature Map (SVTM) will be defined by the data taken by OTES, the onboard thermal emission spectrometer. We will identify the coldest locations where the volatiles and organic matter may be best preserved on the surface of Bennu. We have subdivided temperature, and referenced it to a global average to colder than global T, average global T, and hotter than global T average avoid the effect of the thermal inertia.

Quantification of Science Value Once all of the needed data is collected and produced by our ground system team, we will produce a semi-quantitative method for weighting different elements that feed into the ISVM based on the four Science Value categories. A weighted scoring system will directly feed into the algorithms of each of the four Science Value Maps to produce a means of quantifying the ISVM for a final, false color graphic display of sample science value across the asteroid surface.

References: [1] Messenger S. et al. (2014) LPSC this volume. [2] Clark B.E. et al. (2011) Icarus 216, 462. [3] Simon-Miller A.A. & Reuter D.C. (2013) LPSC 44, 1100. [4] Sandford S.A. et al. (1991) Astrophys. J. 371, 607. [5] Bradley J.P. (1994) 265, 925. [6] Brearley A.J. (1993) GCA 57, 1521. [7] Keller L.P. et al. (2009) MetSoc 72, 5371. [8] Nakamura-Messenger K. et al. (2011) MAPS 46, 843.